A Study on Improving the Profitability of Option Spread Strategies by Using Implied Volatility – Evidences from Weekly TAIEX Options

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Abstract

This study develops an improved bull spread and bear spread strategy, which is created by respectively buying and selling a call option (put option) at a relatively undervalued price and a relatively overvalued price based respectively on the minimal and maximal implied volatility. The made bull spread and bear spread is then held to maturity. Besides, this study endeavors to boost up the settlement profit through using the trading filter depended on volatility difference and expected profit. The weekly TAIEX options are taken as the empirical object to verify the profitability for this improved spread strategy. The empirical results show that the proposed spread strategy associated with implied volatility can earn a sizable settlement profit. Overall, the settlement profit obtained from put spread is relatively better than that of the call spread. Moreover, the profitability is significantly advanced when cooperating with the trading filter, especially when using the expected profit screening criteria.

Keywords: Implied volatility, Option spread strategy, Bull spread, Bear spread, TAIEX options

JEL Classifications: G11

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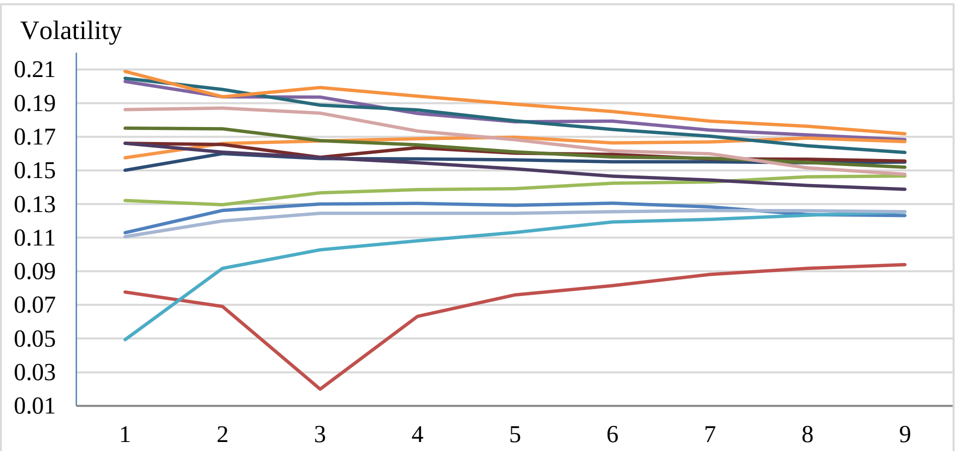
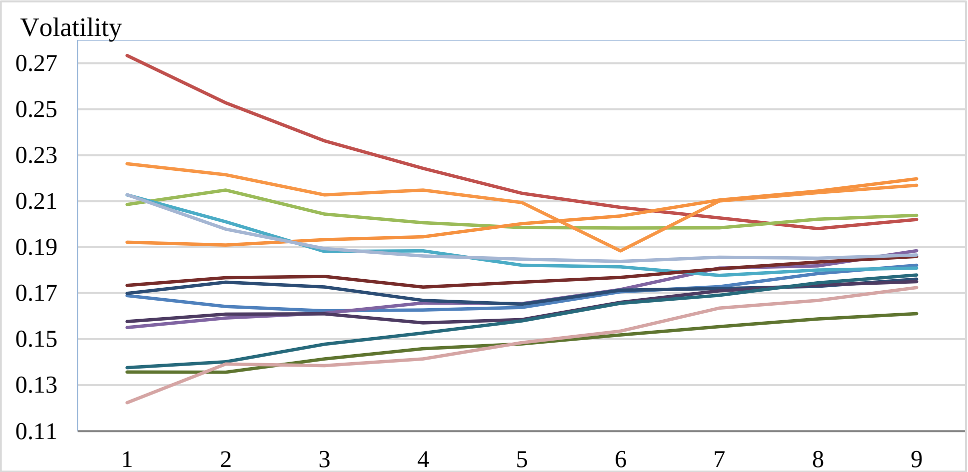
1. Introduction

As generally realized, option price is comprised of exercise (intrinsic) value and time value, and therein, the time value is related to the volatility of underlying asset price. Accordingly, option pricing models have to incorporate the volatility parameter. Unfortunately, the volatility cannot be directly observed and gathered, and thus has to be estimated by means of an effective estimating approach. In present, there are two common approaches to estimate the volatility: historical volatility and implied volatility. Among them, implied volatility is the volatility implied by option prices observed in the market. Therefore, the implied volatility based on option market price has been commonly considered as representing the future expected volatility for the underlying asset price between trading day and maturity date. By its very nature, the implied volatility is what the pricing models just require and nowadays, traders usually work with.

However, a dilemma will definitely encounter when estimating the implied volatility. Namely, the implied volatilities estimated from the series of options with the same underlying asset and maturity date will vary with different exercise prices. These implied volatilities often distribute in a specific pattern, which is referred to as volatility smile and illustrated by examples of weekly TAIEX options. Figure 1 shows the distribution patterns of implied volatilities for the nine weekly TAIEX options at each trading period during the third quarter of 2020 in this empirical study (including a total of 14 weeks). The number in the abscissa represents the exercise prices of call options and put options for each trading period and is arranged from smallest to largest. Figure 1 demonstrates the distribution patterns that call options implied volatilities tend to be skew toward lower right, while put options implied volatilities tend to be skew toward lower left. Such patterns seem to appear frequently in practice and imply that deeper in-the-money the option is, the higher the implied volatility for the both call options and put options.



(A) Weekly TAIEX call options



(B) Weekly TAIEX put options

Figure 1: Implied volatility distribution patterns for weekly TAIEX options (evidences from the third quarter of 2020)

However, an asset should have only one price volatility over a given time period, meaning that there will only be one volatility for a series of options with the same underlying asset and maturity date regardless of exercise prices. Therefore, the implied volatility should be also only one outcome. Faced with this situation, an effective approach must be adopted to prudently determine a single optimal estimate of future price volatility among a variety of implied volatility outcomes for the given underlying asset. In general, the resulting implied volatility estimate is usually a certain acceptable compromise. If this compromise represents the closest volatility to the future real volatility considered by option traders, the options prices whose implied volatilities are comparable higher or lower is likely to be overvalued or undervalued. In view of this, this study focuses on applying the relationship between implied volatility and option price to the bull spread and bear spread, thereby enhancing the success probability and profitability.

In general, bull spread and bear spread takes a lower risk as a result of the offsetting effect caused by opposite trading positions, so that bull spread and bear spread will end up either a limited loss or a limited gain when the options expire. Traditionally, the use of bull spread (bear spread) is mainly based on the expectation of future rises (falls) in the underlying asset price. Consequently, the traders still need to correctly forecast the price movement during a given period, but this is not easy. Instead, this study deems that if the traders can buy a call option (put option) at a relatively undervalued price and sell a call option (put option) at a relatively overvalued price, they would sizably improve the trading advantage and probability by contrast with the traditional spread strategy. Meantime, the implied volatility can effectively help find out the call options and put options whose prices (premiums) are relatively overvalued or relatively undervalued.

In addition, this study also proposes two trading filters to help further the profitability for implied volatility-based bull spread and bear spread. One of trading filters is to create in advance trading screening criteria based on the statistics of the difference between maximum and minimum implied volatilities of each trading period in past specified interval. Trades are made only if the implied volatility differences of any trading period meet the given screening criterion. The second trading filter is to create trading screening criteria based on the statistics of the expected profit of each trading period in past specified interval. Similarly, trade is made only if the expected profit estimated for a certain trading period exceeds the given acceptable screening criterion. Finally, this study takes the weekly TAIEX options as the empirical object to examine and verify the profitability for applying implied volatility and trading filters in the bull spread and bear spread. The reasons are that there are fewer sudden interference events during the shorter weekly contracts so that the option pricing model parameters including price volatility are relatively stable, and thus resulting implied volatility is liable to be more accurate and reliable in the short term.

2. Literature Review

Because of increasing applications of implied volatility on options pricing and hedging, many scholars have been attracted to the study field related to implied volatility in recent years. For example, for the topic on the implied volatility estimation, Poon and Granger (2003) argued that implied volatility should be the best estimate for price volatility of underlying asset under assuming that the market price has fully reflected all relevant information involving underlying asset. Lee, et al. (2006) compared several countries on using implied volatility to develop the formulating approaches for volatility index, and then, the study also used TAIEX options to simulate the volatility index of TAIEX so as to find the most suitable formulating approach. Wang and Hsieh (2009) compared the forecasting effect of different volatility models, and took ARFIMA as the long-term memory time series model and compared it with the two short-term memory time series models of ARMA and GARCH. At the same time, after revising the VIX formulating method that was newly launched by CBOE, a TVIX, which was reckoned as to be most suitable for the trading characteristics of TAIEX options, was created, and treated it as the representative for the implied volatility model.

Lee (2012) used the nonlinear panel unit root test to verify the stability of implied volatility time series data obtained from TAIEX options, and the empirical study found that implied volatility has the property of nonlinear mean reversion. Pan and Wu (2016) explored the relative reaction capability of short-term and long-term option prices. The study used the trading prices of out-the-money options to estimate implied volatilities, and took the near-month and far-month TAIEX options as the empirical objects. The empirical result revealed that there was a low reaction phenomenon from 2005 to 2008, and there was no wrong reaction phenomenon from 2009 to 2013, suggesting that the market efficiency of TAIEX options has been improved. Yuan and Chen (2018) also supported that implied volatility calculated according to distinct market prices is often different, and asserted that market imperfection is one of main reasons for the difference in implied volatility outcomes. Besides, the differences in transaction costs and diverse market structures lead to inconsistencies in information transmission speed for different markets.

For the related studies, which focused on the distribution pattern of implied volatility, Vagnani (2009) claimed that implied volatility shows a smile pattern because traders judge the uncertainty of underlying stock price according to their own subjective forecasts. Consequently, heterogeneity of traders and formation of forecasting outlooks have a certain impact on both equilibrium price and implied volatility. Wu and Pan (2013) concluded that if the market is efficient and the pricing model is correct, implied volatility should not change significantly from exercise price to exercise price. The study worked out implied volatility of TAIEX options between 2005 and 2012, and the empirical results found that implied volatility of in-the-money call options is higher than that of out-the-money put options with the same exercise price and TAIEX options does possess a smile feature.

Chen, el al. (2013) examined the volatility smile characteristic for options on volatility index (VIX options), and found that implied volatility of VIX options have the following characteristics. Implied volatility rises with the increase in exercise price, and its volatility approximately shows a smile profile from bottom left to upper right that is contrary to common stock options. Implied volatilities for longer-term options are smaller. The shorter the duration of options, the steeper the volatility smile, that is, the difference of implied volatility between in-the-money options and out-the-money options increases. Wang (2019) proved that implied volatility of TAIEX options will become greater as toward to deeper in-the-money and out-the-money. Therefore, it shows a tendency to be volatility smile, and the implied volatility curve is not symmetrical and its lowest point locates in the highest exercise price.

Regarding the study field on looking at the causes of implied volatility skew, Chen, et al. (2010) used the unstable rational speculation theory to effectively identify the main origin being attributed to the perceived volatility caused by market makers having a specified prospect on the future market trend. Doran, et al. (2007) and Yuan, et al. (2016) went to exploring the reasons for formation of skew characteristic and their correlation with traders' hedging behavior, and these two studies ultimately indicated that implied volatility skew extent may involve information with the risk discount of volatility risk and large jump in market price. In addition, some researchers concentrated on other related issues such as the structure of implied volatility and the cause of the skew occurrence (Zhang and Xiang, 2008; Doran and Krieger, 2010; Yan, 2011; Mixon, 2011; Gerhold, et al. 2016; Figueroa-López1 and Ólafsson, 2016). In conclusion, most of above studies suggest that implied volatility skew may be related to such factors as distribution pattern for return rate of underlying asset price or risk aversion in the face of severe market fluctuation caused by major systemic risks, as well as discontinuous price jump.

Another study area is the implied volatility function patterns, such as Dumas, et al. (1998), Heston and Nandi (2000), and Wang and Wu (2016) have all aimed at finding deterministic volatility function patterns for the purposes of volatility forecasting. Harvey and Whaley (1992), and Jorion (1995) also used the implied volatility function to develop trading strategies and applied these proposed strategies to verify the efficiency of option markets. Kuo, et al. (2009) introduced the asymmetric time series method and the dynamic implied volatility function with such variables as relative in-the-money or out-the-money proportion. The function developed by their study has the most appropriate description for the real implied volatility structure. Kuo, et al. (2013) examined that whether common factors exist in the implied volatility sequences of TAIEX call options and electronics sector index call options, and analyzed dynamic variation behavior after the implied volatility difference of these two options deviates from the equilibrium via using mean reversion model.

As for the related studies focusing on the trading strategies via using implied volatility, Galai and Schreiber (2013) proposed a simultaneous estimation of bid-ask spreads (BAS) and implied volatility (IV). The study examined the behavior of the key players during relatively turbulent and tranquil periods, and found substantial differences in BASs among key players while insignificant differences in IV. Atilgan, et al. (2015) investigated the intertemporal relation between volatility spreads and expected returns on the aggregate stock market. The study provided evidence for a significantly negative link between volatility spreads and expected returns at the daily and weekly frequencies.

Gao, et al. (2020) investigated the stock return predictability of call-put implied volatility spread through the lens of investor attention. The study found that as investor attention heightens, the volatility spread return predictability becomes more pronounced. Kim, et al. (2020) investigated the cross-sectional implication of informed options trading across different strike prices and maturities. The study found that the shape of the long-term implied volatility curve exhibits extra predictive power for stock returns of subsequent months even after orthogonalizing the short-term components. Han and Li (2021) proved that aggregate implied volatility spread (IVS), defined as the cross-sectional average difference in the implied volatilities of at-the-money call and put equity options, is significantly and positively related to future stock market returns at daily, weekly, and monthly to semiannual horizons.

Up to now, infrequent studies have looked at the options' trading strategies by means of implied volatility. Yang, et al. (2011) made use of the implied volatility difference between call options and put options to conduct an empirical study of the proposed investment strategy from 2007 to 2008, and empirical results showed that the average return rate ranging from between 0.5% to 0.8% could be obtained every day without considering transaction costs. Huang and Wang (2022) demonstrated the implied volatility skew phenomenon with TAIEX options, and pioneered the concept of implied volatility skew spreads. The empirical results that obtained from the experiment on TAIEX options showed that under long-term trading, the implied volatility skew spreads do yield a considerable cumulative positive return. This study basically extends the study works of Yang, et al. (2011) and Huang and Wang (2022) to apply in the customary bull spreads and bear spreads. Additionally, this study is the first to propose taking the expected settlement profit as trading filter to cooperate with spread strategy in order for advancing the settlement profit.

3. Study Methods

As early as 1978, Schmalensee and Trippi (1978) developed a formula to compute the implied volatility estimate through solving Black-Scholes pricing model numerically for the variable which measures the market's expectation of the stock's volatility by option premium. Subsequent scholars, including this study, basically refer to their method. The estimating process for implied volatility involving in this study is explained as follows. As mentioned-above, this study takes the TAIEX options as the empirical object and the TAIEX options are European options on stock index, so the following pricing models for the prices of a European call option on stock index and a European put option on stock index are used to obtain the implied volatility of the TAIEX options.

$$C = S \times e^{-qT} \times N(d_1) - K \times e^{-rT} \times N(d_2) \quad (1)$$

$$P = K \times e^{-rT} \times N(-d_2) - S \times e^{-qT} \times N(-d_1) \quad (2)$$

$$d_1 = \frac{\ln(S/K) + (r - q + \sigma^2/2) \times T}{\sigma \times \sqrt{T}}$$

$$d_2 = \frac{\ln(S/K) + (r - q - \sigma^2/2) \times T}{\sigma \times \sqrt{T}}$$

The function N(x) is the cumulative probability distribution for a standardized normal distribution. The mode parameters K is the exercise price, r is the continuously compounded risk-free rate, q is the average annualized dividend yield rate on the component stocks of given stock index, σ is the annualized volatility of the stock index, and T is the time to maturity of the option. These two pricing models can be used not only to estimate theoretical prices for call options and put options, but also to calculate implied volatility. The implied volatility is the value of which, σ is reversely solved when the actual market trading price (premium) of C (P) for call option (put option) is substituted into formula (1, 2) and the values of other model parameters are brought in the pricing models. Nevertheless, the calculation of implied volatilities are not easy, this study takes their values from Taiwan Economic Journal (TEJ).

3.1. Bull Spread and Bear Spread

As stated earlier, lower and higher implied volatilities are likely to correspond respectively to unreasonably low and high options prices. In the meantime, traders can buy a call option (put option) with a relatively undervalued price and concurrently sell a call option (put option) with a relatively overvalued price to carry out a bull spread (if exercise price for buying option is lower) or a bear spread (if exercise price for buying option is higher). Table 1 displays the trading ways for four spread strategies considered in this study, and also provides the calculations for break-even price, settlement profit, and maximum gain and maximum loss when spread position is held to the expiration date.

Table 1: Trading ways and settlement profit for bull spread and bear spread

Spread strategy	Trading way	Break-even price (*BEP*)	Settlement profit	Maximal gain (*G*) and Maximal loss (*L*)
Bull call spread	(1) Buy a call option with a lower exercise price (2) Sell a call option with a higher exercise price	$K_{c1} - P_{K_{c2}} + P_{K_{c1}}$	$\begin{cases} P_{K_{c2}} - P_{K_{c1}}; & S_T \le K_{c1} \\ S_T - BEP; & K_{c1} < S_T < K_{c2} \\ K_{c2} - BEP; & S_T \ge K_{c2} \end{cases}$	$G = K_{c2} - BEP$ $L = P_{K_{c2}} - P_{K_{c1}}$
Bull put spread	(1) Buy a put option with a lower exercise price (2) Sell a put option with a higher exercise price	$K_{p2} - P_{K_{p2}} + P_{K_{p1}}$	$\begin{cases} K_{p1} - BEP; & S_T \le K_{p1} \\ S_T - BEP; & K_{p1} < S_T < K_{p2} \\ P_{K_{p2}} - P_{K_{p1}}; & S_T \ge K_{p2} \end{cases}$	$G = P_{K_{p2}} - P_{K_{p1}}$ $L = K_{p1} - BEP$
Bear call spread	(1) Buy a call option with a higher exercise price (2) sell a call option with a lower exercise price	$K_{c1} + P_{K_{c1}} - P_{K_{c2}}$	$\begin{cases} P_{K_{c1}} - P_{K_{c2}}; & S_T \le K_{c1} \\ BEP - S_T; & K_{c1} < S_T < K_{c2} \\ BEP - K_{c2}; & S_T \ge K_{c2} \end{cases}$	$G = P_{K_{c1}} - P_{K_{c2}}$ $L = BEP - K_{c2}$
Bear put spread	(1) Buy a put option with a higher exercise price (2) sell a put option with a lower exercise price	$K_{p2} - P_{K_{p2}} + P_{K_{p1}}$	$\begin{cases} BEP - K_{p1}; & S_T \le K_{p1} \\ BEP - S_T; & K_{p1} < S_T < K_{p2} \\ P_{K_{p1}} - P_{K_{p2}}; & S_T \ge K_{p2} \end{cases}$	$G = BEP - K_{p1}$ $L = P_{K_{p1}} - P_{K_{p2}}$

Note: The definition for symbols used in Table1 is as follows. K_{c2} and K_{c1} represents respectively higher and lower exercise price for call options. K_{p2} and K_{p1} represents respectively higher and lower exercise price for put options. $P_{K_{c2}}$ and $P_{K_{c1}}$ represents the price (premium) of call option with a exercise price K_{c2} and K_{c1} respectively. $P_{K_{p2}}$ and $P_{K_{p1}}$ represents the price (premium) of put option with a exercise price K_{p2} and K_{p1} respectively.

3.2. Spread Strategy Creation and Settlement Profit Calculation

3.2.1. Spread Strategy Creation

Follow the described-below steps to make a bull spread and a bear spread for each trading period.

(1) Up to nine implied volatilities (4 out-the-money options, 1 at-the-money option, and 4 in-the-money options) respectively for weekly TAIEX call options and put options, which have just listed to be traded in this trading period, are collected. Next, arrange these resulting implied volatilities from largest to smallest, separately for call options and put options.

(2) Then, buy a call option and a put option with which they have a minimal implied volatility, and concurrently sell a call option and a put option with which they have a maximal implied volatility, thereby making respectively a call spread and a put spread.

(3) These two spread positions are held until the expiration date. Then, their settlement profits are calculated according to the last settlement price.

Finally, the cumulative settlement profits from summing up all trading periods for call spread and put spread are analyzed in order to verify whether the use of implied volatility to create the option spreads indeed has a significant trading advantage. Besides, the difference of settlement profit obtained respectively from call spread and put spread is compared.

3.2.2. Settlement Profit Calculation

The settlement profit calculations for these two types of call spread and put spread are as follows:

1. Call spread

$$Max\{(S_T - K_{pc}) \times M, 0\} - C_p \times M - TC_{pc} + Min\{(K_{sc} - S_T) \times M, 0\} + C_s \times M - TC_{sc} \qquad (3)$$

2. Put spread

$$Max\{(K_{pp} - S_T) \times M, 0\} - P_p \times M - TC_{pp} + Min\{(S_T - K_{sp}) \times M, 0\} + P_s \times M - TC_{sp} \qquad (4)$$

In the above formula, K_{pc}, K_{sc}, K_{pp} and K_{sp} represents respectively the exercise price of buying a call option, selling a call option, buying a put option and selling a put option. C_p, C_s, P_p and P_s represents respectively the price (premium) of buying a call option, selling a call option, buying a put option and selling a put option. S_T is the last settlement price, and M is the contract multiplier (the contract multiplier of TAIEX options is presently \$50 / point).

TC_{pc}, TC_{sc}, TC_{pp} and TC_{sp} denotes respectively transaction cost of buying a call option, selling a call option, buying a put option and selling a put option. Transaction cost includes transaction tax and transaction fees. The present transaction tax rate for TAIEX options is one in a thousand, so transaction tax is amount of premium multiplied by one thousandth. Transaction fee charged by each futures broker is different. This study assumes that spread trading is made by such a professional institute that a preferential fee of about \$10 per lot should be available due to a large trading volume, so transaction fee in this empirical study is calculated at \$10 per lot. When held at maturity, in accordance with the current settlement rule, a out-the-money option and at-the-money option, which will be not exercised, is exempt from transaction tax and transaction fee, while an in-the-money option will be exercised and subject to a transaction tax, which is equal to last settlement price (S_T) $\times$ contract multiplier $\times$ (2/100,000), and a transaction fee.

3.3. Trading Filter Formation

As mentioned-above, this study also intends to develop two efficient trading filters, which will be supportively applied in bull spread and bear spread proposed here, to filter out and exclude those trading periods that are less profitable likelihood. After doing that, an empirical study is conducted to identify whether the proposed trading filters can help enhance the profitability.

3.3.1. Volatility Difference Trading Filter

Volatility difference is defined as the difference between maximal and minimal implied volatilities, that is, $IV_{\max,t} - IV_{\min,t}$; $t = 1,2,3...$. The volatility difference trading filter is created as follows. Firstly, volatility difference of each trading period during the empirical time period is calculated for call spread and put spread, respectively. Next, the main statistics of volatility difference is then determined, and several workable trade screening criteria are formed through making use of the resulting statistics.

3.3.2. Expected Profit Trading Filter

Referring to the pertinent formulas in Table 1, this study derives following four formulas to estimate respectively the expected settlement profit of bull spread and bear spread.

1. Call spread

(1) Bull call spread

$$\begin{aligned} E(R) = &[(K_{c2} - BEP)\times P(S_T \geq K_{c2}) + (K_{c2} - BEP)/2\times P(K_{c2} > S_T \geq BEP)] \\ &-[(P_{K_{c1}} - P_{K_{c2}})/2\times P(BEP \geq S_T > K_{c1}) + (P_{K_{c1}} - P_{K_{c2}})\times P(S_T \leq K_{c1})] \end{aligned} \tag{5}$$

(2) Bear call spread

$$\begin{aligned} E(R) = &[(P_{K_{c1}} - P_{K_{c2}})\times P(S_T \leq K_{c1}) + (P_{K_{c1}} - P_{K_{c2}})/2\times P(BEP \geq S_T > K_{c1})] \\ &-[(K_{c2} - BEP)/2\times P(K_{c2} > S_T \geq BEP) + (K_{c2} - BEP)\times P(S_T \geq K_{c2})] \end{aligned} \tag{6}$$

The relevant probabilities in formula (5, 6) are estimated as follows:

$$a = \frac{\ln\left(\frac{K_{c2}}{S}\right)}{(IV_{\max} + IV_{\min})/2\times\sqrt{1/52}} \tag{7}$$

$$b = \frac{\ln\left(\frac{BEP}{S}\right)}{(IV_{\max} + IV_{\min})/2\times\sqrt{1/52}} \tag{8}$$

$$c = \frac{\ln\left(\frac{K_{c1}}{S}\right)}{(IV_{\max} + IV_{\min})/2\times\sqrt{1/52}} \tag{9}$$

$$P(S_T \geq K_{c2}) = 1 - N(a) \tag{10}$$

$$P(K_{c2} > S_T \geq BEP) = N(a) - N(b) \tag{11}$$

$$P(BEP \geq S_T > K_{c1}) = N(b) - N(c) \tag{12}$$

$$P(S_T \le K_{c1}) = N(c) \tag{13}$$

2. Put spread

(1) Bull put spread

$$\begin{aligned} E(R) = &\left[(P_{K_{p2}} - P_{K_{p1}}) \times P(S_T \ge K_{p2}) + (P_{K_{p2}} - P_{K_{p1}})/2 \times P(K_{p2} > S_T \ge BEP)\right] \\ &- \left[(BEP - K_{p1})/2 \times P(BEP \ge S_T > K_{p1}) + (BEP - K_{p1}) \times P(S_T \le K_{p1})\right] \end{aligned} \tag{14}$$

(2) Bear put spread

$$\begin{aligned} E(R) = &\left[(BEP - K_{p1}) \times P(S_T \le K_{p1}) + (BEP - K_{p1})/2 \times P(BEP \ge S_T > K_{p1})\right] \\ &- \left[(P_{K_{p2}} - P_{K_{p1}})/2 \times P(K_{p2} > S_T \ge BEP) + (P_{K_{p2}} - P_{K_{p1}}) \times P(S_T \ge K_{p2})\right] \end{aligned} \tag{15}$$

The relevant probabilities in formula (14, 15) are estimated as follows:

$$a = \frac{\ln\left(\frac{K_{p2}}{S}\right)}{(IV_{\max} + IV_{\min})/2 \times \sqrt{1/52}} \tag{16}$$

$$b = \frac{\ln\left(\frac{BEP}{S}\right)}{(IV_{\max} + IV_{\min})/2 \times \sqrt{1/52}} \tag{17}$$

$$c = \frac{\ln\left(\frac{K_{p1}}{S}\right)}{(IV_{\max} + IV_{\min})/2 \times \sqrt{1/52}} \tag{18}$$

$$P(S_T \ge K_{p2}) = 1 - N(a)$$

$$P(K_{p2} > S_T \ge BEP) = N(a) - N(b) \tag{19}$$

$$P(BEP \ge S_T > K_{p1}) = N(b) - N(c) \tag{20}$$

$$P(S_T \le K_{p1}) = N(c) \tag{21}$$

Among them, S is current price of underlying asset (i.e. TAIEX), $IV_{\max}$ and $IV_{\min}$ represents respectively maximal implied volatility and minimal implied volatility in that trading period, and N(.) signifies the standard normal cumulative probability function as before. The remaining symbols are the same as defined in Table 1. It should be emphasized that because the expected settlement profit is only used as a trading filter, transaction cost is not taken into account.

This study proposes four screening criteria for each of these two trading filters, including mean, unilateral truncated mean, bilateral truncated mean, and median. Finally, the cumulative settlement profits obtained from bull spread and bear spread with and without using trade screening criteria are compared to verify whether the cumulative settlement profit improves significantly when applying the trade screening criteria in the bull spread and bear spread proposed here.

3.4. Sample Selection and Empirical Design

Empirical data is collected at the close of the first day of the new listing weekly TAIEX options (launching on Wednesday and expiring on next Wednesday) for each trading period. This study allows for the typical reality that the farther away from at-the-money option, the rarer the trading volume. However, as mentioned earlier, overvalued and undervalued prices are more probable to occur in the deeper in-the-money and out-the-money options. Accordingly, under the compromise, this study takes one at-the-money option, four nearest in-the-money options and four nearest out-the-money options per trading period, so there are respectively up to nine weekly TAIEX call options and nine weekly TAIEX put options samples in each trading period. Among these options, if any option is not traded within 5 minutes of closing, it will be excluded, and that trading period will be removed if more than 3 out of 9 samples exclude. The empirical study is performed from January 2013 to December 2020. After removing those incomplete trading periods, a total of 405 trading periods (weeks) are conducted for the purpose of performing this empirical analysis.

Consequently, these two call options and two put options, which have respectively the maximal and minimal implied volatilities, are individually picked out to form a bull spread or a bear spread and held to maturity. Also, this study reasonably assumes that all bull spreads or bear spreads are formed in the closing and thus dealt at the closing prices for picked options. Finally, the last settlement price of each trading period is acquired from Taiwan Futures Exchange in order to figure out the settlement profit of spread strategy proposed here for each trading period. The empirical sample data used in this study are essentially from Taiwan Futures Exchange and Taiwan Economic Journal (TEJ).

4. Empirical Results and Analysis

4.1. Profitability Analysis

After conducting bull spread or bear spread of call options and put options for all 405 trading periods, the resulting settlement profits for each trading period are calculated. Subsequently, the cumulative settlement profits and the average settlement profits are also determined. Tables 2 and 3 shows the descriptive statistics for empirical results of TAIEX call options and put options, of which the cumulative settlement profit and the average settlement profit per trading period for call spread and put spread is $52,825 and $130, and $214,748 and $530, respectively. It thus evidently reveals that call spread and put spread as expected gets a positive return, and the profitability of put spread is significantly higher than call spread. Overall, in addition to positive return ratio that is 50.61% vs. 48.64%, put spread are obviously superior to call spread in the rest of performance indicators.

A more detailed observation and comparison is carried on, one of which is to think about the profitability in terms of annual average return. The call spread and put spread is converted into an annual average settlement profit of $6,603 and $26,844, respectively, it is noticed from this result that put spread is far better than call spread about 4.07 times. In addition, when comparing average return rate per trading period (average settlement profit per period/ average premium paid per period), Tables 2 and 3 show that average return rate of each period for the call spread and put spread turns out to be 2.82% and 9.36%, respectively, and implied annual average return rates is about 146.64% and 486.72%, respectively. Obviously, put spread is far more profitable. These results thus prove that spread strategy based on implied volatility really provides a substantial return. Moreover, return rate of put spread is relatively more advantageous as a result of average settlement profit from all gain periods of put spread being significantly higher than average settlement loss from all loss periods, while call spread is almost equivalent.

There are also three findings from the empirical results, one of which is that the winning rate of bull spread for call options and put options is respectively as high as 64.04% and 55.78%, and notably exceeds bear spread. Secondly, the number of bear spread within call options is relatively large, meaning that implied volatilities of call options with higher exercise prices in most cases are relatively lower, while implied volatilities of lower exercise prices are relatively higher. Therefore, as generally expected, call option shows a downward skew to the right. However, implied volatilities of put options are not apparently inclined to a downward skew to the left as general expectations.

Third, it can be observed from Tables 2 and 3 that both call options and put options are gainful for bull spread and losing for bear spread. This result is presumed that average volatility difference of bull spread of 5.3305% and 5.3218% for call options and put options is quite a higher than corresponding average volatility difference of bear spread of 4.8812% and 4.3053%, particularly put options. Why volatility difference of bull spread is higher? The reason may be that bull call spread appears more in rising market because speculators tends to buy call options with higher exercise price, and bull put spread more appears in the falling market because hedgers tends to buy put options with higher exercise price, both of which make call options and put options with higher exercise price more likely to be overvalued, which also make their implied volatility higher and result in an increase in volatility difference. Nevertheless, since average settlement profit per trading period of bull spread is much higher than that of bear spread, especially put options, overall gain of bull spread is higher than overall loss of bear spread, so that call spread and put spread still gets a sizable positive return.

Table 2: Empirical results analysis for weekly TAIEX call spread

	All spread	Bull spread	Bear spread
Number of trading period	405	178	227
Cumulative settlement profit	52,825	176,242	-123,417
Number of winning (Winning ratio)	205 (50.61%)	114 (64.04%)	91 (40.09%)
Mean of settlement profit	130	990	-544
Median of settlement profit	52	1,199	-1,023
Standard deviation of settlement profit	5,487	4,934	5,818
Minimum of settlement profit	-18,973	-10,256	-18,973
Maximum of settlement profit	13,362	12,224	13,362
Average return rate *	2.82%	11.65%	-34.17%
Average gain for winning periods	4,477	3,891	5,210
Average loss for losing periods	-4,325	-4,177	-4,394
Average volatility difference	5.0741%	5.3305%	4.8812%

Table 3: Empirical results analysis for weekly TAIEX put spread

	All spread	Bull spreads	Bear spreads
Number of trading period	405	199	206
Total cumulative profits	214,748	293,866	-79,118
Number of winning (winning ratio)	197 (48.64%)	111 (55.78%)	86 (41.75%)
Mean of settlement profit	530	1,477	-384
Median of settlement profit	-181	842	-1,391
Standard deviation of settlement profit	5,348	4,603	5,860
Minimum of settlement profit	-16,637	-16,637	-9,785
Maximum of settlement profit	12,815	12,815	11,426
Average return rate per period *	9.36%	51.79%	-4.58%
Average gain for winning periods	5,045	4,693	5,500
Average loss for losing periods	-3,746	-2,580	-4,601
Average volatility difference	4.8047%	5.3218%	4.3053%

4.2. Improvement Analysis Using Volatility Difference–based Trading Filter

First of all, this study intends to examine whether there is a positive correlation between implied volatility difference and settlement profit. That is, when volatility difference is greater, more likely it is to earn a higher settlement profit through making a bull spread or a bear spread. The nature of implied volatility for weekly TAIEX options during empirical time period is analyzed in advance. Table 4 shows the descriptive statistical analysis for minimal implied volatility, maximal implied volatility and volatility difference of each period. Among others, there are three major findings, one of which is that means are all higher than medians, so they appear a rightward skewness, meaning that a small number of extreme values exist for both implied volatility and volatility difference.

Next, implied volatility of put options is significantly higher than that of call options, meaning that the price of put options is more likely to be relatively overvalued, which also explain why put spread is more profitable. Finally, the dissimilarity is that volatility difference of call options is relatively higher than that of put options, and average volatility difference of call options and put options is 5.0741% and 4.8047%, respectively. This result exactly reflects why positive return ratio of call options in Table 2 is higher, but the overall settlement profit is not as good as that of put options as a result of lesser average settlement profit per trading period.

Table 4: Descriptive statistical analysis for volatility difference

	Implied volatility of call options			Implied volatility of put options		
	Minimum	Maximum	Difference	Minimum	Maximum	Difference
Mean	8.2321%	13.3063%	5.0741%	12.1335%	16.9013%	4.8047%
Median	8.3576%	12.2833%	4.5066%	11.6414%	15.4962%	3.7895%
Standard deviation	5.4406%	5.0569%	3.3725%	6.5553%	6.4817%	3.3628%
Minimum	0.0485%	6.8280%	0.6708%	0.0279%	7.5397%	0.6805%
Maximum	40.5195%	47.4976%	30.2261%	76.1140%	78.3349%	24.2817%

Regression analysis, which takes volatility difference as independent variable and settlement profit as dependent variable, is then run, and regression result is outline in Table 5. Table 5 shows that intercept term of call options is significantly negative and put options is not significantly negative. However, these two regression coefficients of volatility difference variable for call options and put options are significantly positive, and the significance of put options is particularly higher. Hence, this regression result clearly indicates that volatility difference has a significant positive impact on settlement profit. According to the values of regression coefficient, when volatility difference increases by 1%, settlement profit of call spread and put spread will increase by about $19,791 and $26,220, respectively. In contrast, put spread has obviously increased even more.

In a word, the above empirical results reveal that though both of them have a significant positive effect, the put spread should be more suitable. Moreover, when volatility difference is bigger, the greater settlement profit could be expected to receive. Therefore, it thus can be concluded from this regression result that volatility difference could serve suitably as an effective trading filter to match bull spread or bear spread proposed in this study, and after doing so, it should have a great chance to boost gainful opportunities and settlement profit.

Table 5: Regression analysis for the relationship between settlement profit and volatility difference

	Call spread			Put spread		
	Coefficient	t-statistic	p-value	Coefficient	t-statistic	p-value
Intercept term	-873.80	-1.7968	0.0731*	-729.57	-1.5921	0.1121
Volatility difference	19791.16	2.4880	0.0132**	26220.18	3.3557	0.0009***
R^2		12.2995%			16.4870%	

Note: ** stands for significance on 5% significant level; *** stands for significance on 1% significant level.

As mentioned-above, this study attempts to find out the effective trade screening criteria by means of volatility difference with the aim of advancing the profitability. To this end, this study proposes four screening criteria, including mean, bilateral truncated mean (removing the minimal first 5% and maximal 5% samples), unilateral truncated mean (removing the first maximal 5% samples), and median. Then, the trading rule is to first calculate volatility difference for each trading period, and a bull spread or a bear spread is only made if volatility difference for that trading period is greater than screening criteria. Tables 6 and 7 exhibits respectively the empirical results of call spread and put spread. As contrasted with no use of trade screening criteria, it is clear that the profitability of call spread and put spread is considerable increase regardless of the use of mean, truncated mean or median as the trade screening criterion.

Among them, positive return ratio of call options and put options increased by about 4% and 9% respectively. In addition, cumulative settlement profit and average settlement profit per trading period is also noticeably improved. Meantime, cumulative settlement profit and average settlement profit for call spread increase respectively by 202.23%, 222.16%, 251.73% and 244.16%, and by 644.62%, 615.38%, 614.62% and 589.23% under the application of mean, bilateral truncated mean, unilateral truncated mean and median screening criterion. On the other hand, under the same conditions, cumulative settlement profit and average settlement profit increase respectively by 14.67%, 21.49%, 31.06% and 52.17%, and by 205.66%, 202.08%, 212.45% and 203.77% for put spread. Overall, the profitability through using median screening criterion seems to perform best, followed by unilateral truncated mean screening criterion. Moreover, profit improvement of call spread is apparently higher, almost all of which are as high as more than twice, mainly because the average loss of losing trading period is greatly reduced, so that net profit between winning trading periods and losing trading periods is substantially enlarged.

Table 6: Empirical results for call spread with using volatility difference screening criteria

Screening criteria	Mean 5.0741%	Bilateral truncated mean 4.7434%	Unilateral truncated mean 4.5488%	Median 4.5066%
Number of trading period	165	183	200	203
Number of winning (Winning ratio)	89 (53.94%)	98 (53.35%)	108 (54.00%)	110 (54.19%)
Cumulative settlement profit	159,652	170,179	185,801	181,802
Growth rate of cumulative settlement profit	202.23%	222.16%	251.73%	244.16%
Average settlement profit	968	930	929	896
Growth rate of average settlement profit	644.62%	615.38%	614.62%	589.23%
Average return rate per trading period	24.64%	22.88%	22.11%	21.26%
Average gain for winning periods	4,687	4,701	4,692	4,619
Average loss for loss periods	-3,388	-3,418	-3,488	-3,508

Table 7: Empirical results for put spread with using volatility difference screening criteria

Screening criteria	Mean 4.8047%	Bilateral truncated mean 4.4717%	Unilateral truncated mean 4.2971%	Median 3.7895%
Number of trading period	152	163	170	203
Number of winning (Winning ratio)	90 (59.21%)	98 (60.12%)	101 (59.41%)	117 (57.64%)
Cumulative settlement profit	246,254	260,895	281,450	326,783
Growth rate of cumulative settlement profit	14.67%	21.49%	31.06%	52.17%
Average settlement profit	1,620	1,601	1,656	1,610
Growth rate of average settlement profit	205.66%	202.08%	212.45%	203.77%
Average return rate per trading period	21.18%	21.34%	22.23%	23.59%
Average gain for winning periods	5,484	5,412	5,545	5,647
Average loss for loss periods	-3,988	-4,147	-4,037	-3,883

4.3. Improvement Analysis Using Expected Profit–based Trade Filter

This section will go on to appraise another trade filter by applying expected profit. More specifically, one would like to realize whether the greater expected profit estimated in advance, the more likely it is to earn a higher settlement profit. Similarly, the important characteristics of expected profit are first analyzed for weekly TAIEX options during the empirical time period. Table 8 illustrates the descriptive statistical analysis of expected winning possibility and expected profit of each trading period. There are three critical results worth explaining, one is that the probability of expected winning for put options is slightly higher than call options, and the probability of expected winning is rather close to actual positive return ratio shown in Tables 2 and 3.

The second is that mean of expected profit is also higher than its median, so it also has a rightward skewness, which means that there may also be a small number of extreme values. The third is that expected profit of call options and put options without considering the transaction cost is $718 and $1,039, and put options is also better than call options, which is consistent with the actual settlement profit shown in Tables 2 and 3.

Table 8: Descriptive statistical analysis for expected profit

	Call options		Put options	
	Probability of expected winning *	Expected profit	Probability of expected winning *	Expected profit
Mean	46.3312%	718	51.6606%	1,039
Median	46.8114%	656	50.3959%	841
Standard deviation	15.5862%	1,241	8.8247%	1,277
Minimum	1.7635%	-13,821	8.4250%	-11,064
Maximum	96.4515%	11,452	88.3735%	15,605

Note: Probability of expected winning for bull spread is $P(S_T > BEP)$; probability of expected winning for bear spread is $P(S_T < BEP)$.

Regression analysis is performed again, but this time with expected profit as independent variable, and regression results are exhibited in Table 9. Empirical results also show that the intercept term of call options is significantly negative, and that of put options is not significantly negative. Additionally, the regression coefficients of call spread and put spread are all very significant positive values, which definitely support that expected profit of call spread and put spread also has a significant positive effect on settlement profit. According to the outcomes of regression coefficient, when expected profit increases by $1, settlement profit of call spread and put spread will increase respectively by $1.2084 and $0.9884, and as contrasted with volatility difference screening criteria, call options obviously increases more.

The above empirical results evidently suggest that call spread and put spread should be very applicable to cooperate with expected profit screening criteria for advancing the profitability. When expected profit is greater, there will be greater potential to enhance winning opportunities and settlement profit.

Table 9: Regression analysis for the relationship between settlement profit and expected profit

	Call spread			Put spread		
	Coefficient	t-statistic	p-value	Coefficient	t-statistic	p-value
Intercept term	-737.35	-2.4264	0.0157**	-496.54	-1.4869	0.1378
Expected profit	1.2084	5.6959	0.0000***	0.9884	4.8679	0.0000***
R^2		27.2957%			23.5656%	

Note: ** represents significance on 5% significant level; *** represents significance on 1% significant level.

Similarly, this study also endeavors to find out the effective expected profit-based trade screening criteria to help boost up the profitability, and uses again above four screening criteria on the basis of expected profit. Alike, expected profit for each trading period is ahead calculated, and when expected profit of a given trading period is better than the pre-determined screening criterion, bull spread or bear spread for that trading period is only made. When the empirical process is completed sequentially, the resulting settlement profit is compared again with that of no use of screening criteria so as to examine the improvement effect on cumulative settlement profit. Tables 10 and 11 shows respectively the empirical results of weekly TAIEX call options and put options. With examining the empirical results of Tables 10 and 11, it can also be found that regardless of the use of the mean, truncated mean or median as trade screening criterion, call spread and put spread is also considerably superior to the unused situation. Furthermore, the profitability seems to be more stable and profitable than volatility difference screening criteria.

Positive return ratio of call options and put options with using expected profit screening criteria is about 2% and 1% higher than those of with using volatility difference screening criteria. In addition, cumulative settlement profit and average settlement profit per trading period also substantially improves. When call spread is along with applying by mean, bilateral truncated mean, unilateral truncated mean and median screening criteria, cumulative settlement profit increases respectively by 268.18%, 244.75%, 298.79% and 262.37%, and average settlement profit increases respectively by 740.77%, 630.00%, 616.92% and 625.38%. In the case of put spread while working in the same condition, cumulative settlement profit increases respectively by 38.44%, 41.44%, 33.21% and 36.74%, and average settlement profit increases respectively by 279.06%, 251.51%, 181.13% and 174.34%. Overall, settlement profit performance from mean screening criterion is relatively superior to other three screening criteria. Moreover, profit improvement of call spread is obviously higher, almost all of which are more than 2.5 times.

Three valuable conclusions can be drawn from the empirical results of trade screening criteria, one of which is that the spread strategy cooperating with the trading filter based on volatility difference and expected profit all do significantly advances settlement profit. On average, cumulative settlement profit and average settlement profit per trading period of call spread and put spread with using expected profit screening criteria increases respectively by 32.51% and 4.91%, and 98.63% and

19.02%. It thus proves that expected profit trading filter should be more beneficial than volatility difference trading filter. The second is that call spread should be more suitable for matching the trading filter, and can even increase settlement profit by more than twice. Finally, it should be better off for volatility difference trading filter using median screening criterion and expected profit trading filter using mean screening criterion.

Table 10: Empirical results for call spread with using expected profit screening criteria

Screening criteria	Mean 718	Bilateral truncated mean 696	Unilateral truncated mean 576	Median 656
Number of trading period	178	192	226	203
Number of winning (Winning ratio)	100 (56.18%)	106 (55.21%)	127 (56.19%)	113 (55.67%)
Cumulative settlement profit	194,492	182,112	210,660	191,425
Growth rate of cumulative settlement profit	268.18%	244.75%	298.79%	262.37%
Average settlement profit	1,093	949	932	943
Growth rate of average settlement profit	740.77%	630.00%	616.92%	625.38%
Average return rate per trading period	25.63%	22.16%	21.25%	21.70%
Average gain for winning periods	5,509	5,538	5,287	5,452
Average loss for loss periods	-4,570	-4,708	-4,654	-4,719

Table 11: Empirical results for put spread with using expected profit screening criteria

Screening criteria	Mean 1,039	Bilateral truncated mean 952	Unilateral truncated mean 873	Median 841
Number of trading period	148	163	192	202
Number of winning (Winning ratio)	91 (61.49%)	99 (60.74%)	110 (57.29%)	114 (56.44%)
Cumulative settlement profit	297,305	303,741	286,070	293,644
Growth rate of cumulative settlement profit	38.44%	41.44%	33.21%	36.74%
Average settlement profit	2,009	1,863	1,490	1,454
Growth rate of average settlement profit	279.06%	251.51%	181.13%	174.34%
Average return rate per trading period	45.55%	41.17%	31.50%	29.73%
Average gain for winning periods	5,486	5,445	5,442	5,580
Average loss for loss periods	-3,543	-3,676	-3,812	-3,891

5. Conclusion and Remarks

As commonly recognized, a series of options with the same underlying asset and expiration date, and different exercise price turn out to be a range of implied volatilities. These implied volatilities often scatter in particular shapes such as positive slope, negative slope or smile curve, also meaning that there may be relatively overvalued or relatively undervalued tendency in the market prices for these series of options. In that case it should be able to get a trading advantage for earning settlement profit provided that trader buys a call option (put option) with a relatively undervalued price (smaller implied volatility), and concurrently sells a call option (put option) with a relatively overvalued price (bigger implied volatility) to carry out a bull spread or a bear spread. Besides, this study also intends to take volatility difference and expected profit as trading filter to cooperate with bull spread and bear spread for the purpose of advancing winning opportunity and settlement profit.

The empirical results can be summarized as follows. Whether it is a call spread or a put spread that is made based on implied volatility, a substantial cumulative settlement profit has finally acquired. Meantime, cumulative profit and average profit per trading period for put spread is far better than those for call spread. Also, there is a significant positive correlation between settlement profit and volatility difference and expected profit, of which expected profit is more significant. This result supports that the use of volatility difference and expected profit as trading filter to cooperate with bull spread and bear spread can help effectively enhance the profitability. Moreover as expected, expected profit trading filter is relatively better for increasing settlement profits. Finally, whereas median screening criterion is suitable for applying in volatility difference trade filter, mean screening criterion is seemly to utilize in expected profit trade filter. In a word, the improved option spread strategy proposed here has a rather high opportunity to successfully make a settlement profit, so this study is confident that the study works and empirical findings should have quite a few reference values for practical application.

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